***Annual Reports will be posted on the RISA webpage. Please ensure that these reports are prepared for external audiences, many of whom may not be very aware of RISA work.*

Template for Annual Report **(20 page limit)**
Due on **June 30, 2017**
In addition to uploading your report to Grants Online, please send a pdf of the report to Darlene Ward at Darlene.ward@noaa.gov. **Please ensure that your responses are in narrative form (not bullet points).**

1. **Award Title** (must match the name on your award):

   California-Nevada Climate Applications Program (CNAP)

2. **Performance Period** (from previous progress report through May 30, 2017):

   May 30, 2016 through May 30, 2017 (through the use of a no cost extension).

3. Who are your **team members**? Please include graduate students and post-doctoral researchers in this list.

   Tim Brown, Daniel Cayan (PI), Michael Dettinger, Alexander Gershunov, Jordan Goodrich, Sam Iacobellis, Julie Kalansky, Daniel McEvoy, Nina Oakley, David Pierce, Amanda Sheffield, Shraddhanand Shukla, Kristin VanderMolen, Tamara Wall (PI), and LeRoy Westerling.

Please describe any new areas of focus and new partnerships from the past year. We use information from questions 4-5 for reporting on NOAA performance metrics; therefore, please only include items in this section that have not been reported in previous annual reports.

4. Do you have any **NEW areas of focus or partnership** that have begun this past year? Please provide some context for why you are expanding into this area or partnership. Include any NEW cross-RISA partnerships.

Cayan, Dettinger, Kalansky and Westerling are working with the State of California on developing new regional sections that will become part of California's 4th Climate Change Assessment. This is the first time that CA has included regional components that are part of the State's Climate Change Assessment reports. The purpose of the regional assessments is to inform and advance science-based climate-aware, resilient planning, project design, and implementation in each region as well as identify knowledge gaps that will lead scientists and practitioners to develop new research studies and pilot projects. Along with other regional author leads, Cayan, Dettinger, Kalansky and Westerling will work with regional stakeholders in various multiple sectors, including transportation, public health, parks and agriculture, to develop the reports. The reports are due out at the end of 2018.

Nina Oakley's research on the meteorological storms that cause debris flows in California has begun to extend to Nevada. Nina presented at the Nevada Silver Jackets Alluvial Fan Flooding Workshop. The Nevada Silver Jackets is an agency in Nevada that evaluates geologic and flood hazards and includes US Army Core of Engineers, NWS, and local planners/engineers. By attending and engaging with the Nevada Silver Jackets, Oakley took note of the lack of information presently available and has begun to explore alluvial fan flooding in Nevada. She was also able to learn from the various stakeholders (emergency managers, city/county engineers, city/county planners, NV Dept of Water Resources) what their information needs are and opportunities for beneficial research.

Cayan. Gershunov, Kalansky and Goodrich are partnering with the Science Climate Alliance, South Coast and working with Alliance ecologists to assess the natural resources at risk from climate change and increased climate variability in San Diego's diverse terrestrial ecosystems. To accomplish this, we have assembled a team of climatologists and ecologists in a unique collaboration. The team has outlined an approach to elucidate existing science and expose knowledge gaps for the San Diego region. Our collaborative group of ecologists and climatologists will describe the rich biodiversity of the region, the efforts that have been made to conserve open spaces and natural resources, and review the state of the science with respect to understanding potential climate impacts on the diverse environmental landscape in the San Diego region. The goal of this collaborative effort is to present a needed assessment of San Diego ecosystems and natural resources futures, which will take stock of the implications of climate change as well as other stressors. We aim to review how San Diego's natural resources are at risk from climate change and co-occurring stressors. Our ultimate aim is to compile and present this assessment to help guide better stewardship and management of the unique ecosystems in the region. The final report from this effort will be presented as part of the 4th California Climate Change Vulnerability and Adaptation Assessment.

Wall is partnering with the Reno Sustainability office, the Nevada State Climate Office, and the University of Nevada, Reno (Geography and English departments) in seeking funding for a joint postdoctoral fellow to support synthesizing current climate information to support climate resiliency planning throughout the State for local and tribal communities. Additionally, this position, if funded will also focus on research examining how climate information is communicated and, interpreted, and utilized in planning by stakeholders, leveraging work with the City of Reno Sustainability Committee, working with Lynda Walsh, a rhetorician in the UNR English Department and Wall, who is a member of the committee.

5. Please tell us which States or territories in your region are using new or tailored climate services (tools, information, technical assistance, or products) as a result of your interaction with decision makers over the past year. Please describe at least one new/tailored climate service per State/territory that you include.

Kalansky, Sheffield, Cayan and Pierce began working on an assessment for Southern Nevada Water Authority (SNWA) on the spatial and temporal climate variability in the region. Using the historical data, with SNWA we determined metrics to evaluate global climate models that best represent the historical climatology of the region. Through rankings and regular conversations with SNWA, we determined the 6 global climate models that best represent SNWA climate. These climate models will next be used for future projections in the region. This information will inform long term water demand projections and capital projects.

In association with the California 4th Climate Change Assessment, Pierce, Cayan and Kalansky have provided California state agencies and the California Governor's Office a set of climate and sea level projections needed in planning. As part of this effort, CNAP researchers are working with state agencies to develop figures and fulfill information requests that are used to communicate climate impacts across various state agencies and to the public. This is a continual and on-going effort as information request come in.

6. A. How are you measuring the overall program-level impact of your RISA team? Please provide information on your evaluation model, including metrics or indicators that you use to evaluate your program.

Under the leadership of Wall, CNAP has developed an evaluation program that will be used to evaluate the impact of CNAP during the next funding cycle. CNAP will work in the first 6-months to develop a detailed evaluation plan for the projects this next year. However, to do this, CNAP will need baseline information to see if and how it is improving and will gain this information through a preliminary self-evaluation that will include interviews with team members and key stakeholders.

Additionally CNAP has a newly developed website with much better data analytics so we can determine who is using the website and what information is being accessed most frequently and by whom. Although statistics are only available for the last month, CNAP has had 133 users with the average session duration being almost 3 minuets. Currently our audience is weighted towards California, but we are looking to expand in the upcoming year with new precipitation tracking tools for Nevada.

B. Please describe your overall program-level impact including (if applicable) a summary of the results from your evaluation efforts.

CNAPs primary programmatic impact in Nevada is that it has built scientific credibility and had become a trusted go-to group for climate information and resilience building in Nevada. CNAP has developed relationships across the state with Tribal, federal, state, and local decision makers and planners through the Great Basin Climate Forums. To demonstrate this, in the last year, CNAP has been contacted by the City of Reno Sustainability Office, the Elko Band, and the Washoe Tribe to provide specific climate and weather information and products related to climate resiliency.

In California, CNAP has been a trusted, credible source of climate related information to key California State Agencies including California Energy Commission, and Department of Water Resources for quite some time. In this part year, CNAP has been working with boundary organizations and other climate services groups, such as the Science Climate Alliance, Associate of Environmental Professionals, and the California LCC to engage with more localized decision makers.

7. How have you helped to build the expertise and ability of local/regional decision-makers to prepare and adapt to climate variability and change?

Cayan was a member of a Working Group of the California Ocean Protection Council Science Advisory Team (OPC-SAT), supported and convened by the California Ocean Science Trust to update the science associated with California's future sea levels (Griggs et al., 2017). The Rising Seas report synthesizes the current understanding and uncertainty associated with sea-level rise in California. The State of California Sea-Level Rise Guidance Document, which provides guidance to state agencies for incorporating sea-level rise projections into planning, design, permitting, construction, investment and other decisions. Now several state agencies in California, are updating this statewide guidance to reflect recent advances in ice loss science and projections of sea-level rise and using the Rising Seas report as the scientific foundation for this update.

Members of CNAP are contributing to the SoCal Climate Alliance, involving sea level rise in San Diego County, ecosystem vulnerability to climate variability and climate change, and the spatial and temporal variability of San Diego County's precipitation, which has broad interest across the Alliance and also to the City of San Diego Water Engineering Department.

Mike Dettinger has developed a Snow and Reservoir Water Storage Tracker, which he distributes regularly to State, Local and Federal stakeholders. Dave Pierce has developed and maintains the California and Southern California Precipitation Tracker, which is provided on the CNAP website to interested users and also to Public Broadcasting System Southern California outlets KPBS and KPCC. Both of these can be seen on the new and improved CNAP website, cnap.ucsd.edu.

8. What is the accomplishment from this past year of which your team is most proud? Why?

Over the past year with the integration of Nevada into the California DEWS, CNAP team members have continually expanded their engagement to a broad set of stakeholders in both California and Nevada. CNAP has increased the attendance on the NIDIS webinar and has engaged with new partners bringing a diversity of experts to the webinars and outlooks. In addition, because so many of the CNAP researchers are involved with NIDIS it has facilitated the mentoring of early career scientists by expert researchers. Through

the mentoring, early career researchers have learned about data availablity, new approaches to analyzing the data, and have begun to build relationships with stakeholders. New representations on the status of the amount of precipitation and water stored in California have been given positive feedback and are becoming a staple in status updates in the region.

For questions 9-12, you can combine these questions for each of the main projects you are highlighting, if it makes sense to do so.

9. Please provide a list of up to 5 **research findings** – Please try to include examples that span disciplinary and interdisciplinary work. Examples might be: a) dust-on-snow reduces Colorado River runoff by 5%, or b) analysis revealing the presence or absence of adaptive capacity in legal and policy frameworks for managing resources. **Please include a brief description of the rationale for the research, including stakeholders engaged, the relevance/importance of the research, and, if applicable, any notable impacts of the research on decision making.**

Work of Tim Brown and Tamara Wall examined the effectiveness of spot weather forecasts for controlled burns. The research showed that key opportunities for improving accuracy and utilization of spot weather forecasts lie in 1) enhancing the processes and mechanisms for communication between a Weather Forecast Office and fire practitioners—before, during, and after an SWFs is issued—and 2) working with the wildland fire community to experiment with forecast uncertainty and confidence information in spot weather forecasts and evaluate impacts of these approaches.

- Wall, T., T. Brown, and N. Nauslar, 2017: Spot Weather Forecasts: Improving Utilization, Communication, and Perceptions of Accuracy in Sophisticated User Groups**.** *Weather, Climate, and Society*, **9**, 215-226.

Through NIDIS Coping with Drought Funding, Shukla was able to examine NMME forecast skill at subseasonal to seasonal (S2S) time scales for California and Nevada. Improved S2S forecasts have been a focus for the Western State Water Council, California Department of Water Resources and agricultural communities. The research has shown skill at seasonal scale forecasts (1 to 3 months) exists in forecasts made in early Jan and Feb. Seasonal scale skill exists in temperature forecasts made in April through June, which is promising for the implication for snowmelt forecasts. The research has also shown that although there is limited skill in forecasting the frequency of extreme precipitation and heatwave level (>90%-ile P, Tmax or Tmin) events, June forecasts, especially over non-costal areas does have some skill.

Dettinger and colleagues developed definitions of "snow drought" with the examples of 2014 and 2015 Sierra Nevada snow droughts foremost in mind. They published a simple set of definitions for describing "dry" vs "warm" snow droughts in Eos in December, definitions that have been picked up pretty widely already in discussions of western droughts and western climate change. These definitions also are right at the heart of what happened in California this winter, with a deep snow drought taking hold early in fall and

early winter, to be broken by the massive snow storms of January and February 2017; without that early "warm" snow-drought period, the Jan-Feb flooding and now springtime snowmelt flooding that California and Nevada are dealing with now would have been far worse. The definitions turned out to be an especially timely publication that put some simple but (apparently) useful ideas into circulation just when they became particularly useful.

Kristin VanderMolen began examining farmer and rancher needs for and use of climate information in contexts of environmental and related sociopolitical change. This study examined drought information use among farmers in Klamath County, Oregon. Increasingly farmers in several Western U.S. states are affected by drought, yet whether and how they use drought information in agricultural decision-making remains relatively unknown. Since 2001, hydrological and associated regulatory drought in the Klamath Basin have affected not only agricultural production and livelihoods, but also tribal communities and endangered fish. Both the severity of drought and the variability in the annual allocation of water among rights-holders suggests that drought information may be of use to farmers seeking to mitigate risk, yet this study finds otherwise. In-depth interviews with Klamath County farmers, ranchers and representatives of government and nongovernmental agricultural organizations reveal that such tools lose their predictive and explanatory value for not reflecting the regulatory nature of drought in the basin. The study suggests that in contexts of regulatory drought, improved monitoring and forecasting of the water resources that factor in determining allocation may be more useful to farmers than access to drought information per se. In so doing, the study highlights the importance of co-production in the development of drought and other climate tools and information for increasing the likelihood that user needs are met.

Westerling and graduate student, Joe Crockett, have examined the nexus between drought and wildfire. Results from their research showed that droughts of the last 15 years (2000-2002, 2012-2014) had more extremes of climatic water deficit than earlier droughts, driven by greater temperature and precipitation extremes. Comparing fire extent and severity before, during and after drought events using the Monitoring Trends in Burn Severity dataset (1984-2014), we found fire size and high severity burn extent were greater during droughts than before or after. Similarly, recent Sierra Nevada forest mortality was greatest in drought-affected locations immediately after the drought. Climate simulations anticipate greater extremes in temperature and precipitation in a warming world: droughts and related impacts of the last 15 years may presage the effects of these extremes.

- Crockett, J. and A.L. Westerling, 2017, Greater temperature and precipitation extremes intensify Western US droughts, wildfire severity, and Sierra Nevada tree mortality. *Journal of Climate*, in review.

10. Please provide a list of up to 5 **outreach or communication activities** that you have undertaken in the past year. OPTIONAL: If applicable, please share the outcomes of these activities. We are particularly interested in measurable or

observed changes in areas such as management practices, planning, policy, and behavior.

The Great Basin Climate Forum was hosted at Desert Research Institute on April 6th. There were over 50 attendees and the topic focused on the very wet winter of this year, and what the implications were for the spring and summer. The presentations reach across sectors and are recorded and made available on the web for those unable to attend. Additionally, facilitators guide managers and specialists through an exercise designed to elicit discussion within and between groups, providing managers the opportunity to communicate additional management concerns and related science needs to specialists. The Great Basin Climate Forum also includes planned breaks to enable personal interaction among managers and specialists who otherwise may not meet. The opportunity to network across agencies and disciplines is commonly highlighted among the primary benefits of participation. 100% of those surveyed after the April 2017 Great Basin Climate Forum reported it to be a productive use of their time and worth continuing in the future.

Kalansky has presented at two Association of Environmental Planners conferences (August 2016 and May 2017). Both presentations were on the current state of the science of climate information available for California, and how and why to use this information in future local planning. In the presentations, Kalansky educated the groups about when and why to use downscaled data and where localities in California can access the LOCA downscaled data (Cal-adapt-beta). In addition Kalansky spoke about the new sea level projections for California and discussed the large uncertainty from Antarctica. These presentations, amongst many on-going conversations in California at all different levels, state, regional, city, are causing localities to incorporate multiple scenarios to account for the uncertainty in sea level rise projections. Additionally, Pierce and Kalansky presented on similar topics at California's Climate Change Symposium, which has a diverse group of stakeholders, including state official, local planners, and researchers from a diversity of sectors.

CNAP researchers Sheffield organized the three NIDIS workshops throughout California to inform the NIDIS strategic plan. The results of these workshops highlighted several important issues in California including the cascading of events that begin with drought, the need for regional monitoring, improved S2S communication and forecasts amongst others. McEvoy, Pierce, Shukla and Kalansky have participated of the NIDIS climate and outlook webinars that Sheffield has organized. In participating in the NIDIS webinars and outlooks, we have highlighted NIDIS DEWS tools, NOAA tools as well discussed the skill in extended range forecasting. In addition to this effort, Sheffield and Shukla, in response to stakeholders requests, produced two different subseasonal to seasonal (S2S) forecasts informational sheets with the objectives of explaining what S2S is, the differences between the types of S2S forecasts (statistical and dynamical), and explaining how to read Climate Prediction Center's S2S forecasts. The development of the S2S handouts was collaborative effort between CNAP, CPC, NIDIS, California Department of Water Resources and NWS. The two-pager can be found on the CNAP website (https://scripps.ucsd.edu/programs/cnap/twopagers/) and the four pager will be released shortly.

CNAP researchers have participated in Weather on Steroids: the Art of Climate Change Science, an exhibition of art inspired by science that is very successful in educating the public about climate science and climate change impacts on our weather, health, water, energy, life. Each exhibit in the art show is a collaboration between a scientist and an artist. Gershunov took a leading role in organizing the exhibition and Dettinger and Pierce worked with artists to provide data and explain the projected changes to water resources highlighting results produced by CNAP work.

Wall, in collaboration with Gigi Owens, CLIMAS; Dr. Alison Meadow, University of Arizona; Chelsea Combest-Frieddman, NOAA, Margaret Hargreaves, Community Sciencce, and Alex Horangic, Unversity of Arizona, organized and presented at the Amereican Evaluation Association Annual Meeting in 2016. The title of the session was *Making Climate Science Useful: Evaluating Co-Produced Climate Science*. The session focused on providing an overview of the key characteristics of co-produced climate science, and presented two case studies of co-produced climate science project evaluations and the metrics and indicators developed. The panel will concluded with a discussion on developing a learning collaborative to develop a body of evidence-based co-produced projects to identify the effectiveness of this approach to climate science research.

11. Please provide a list of **key publications** from the past year. We are seeking ~ 5 publications that you wish to highlight, with a brief abstract/description. These can be either non-peer reviewed or peer-reviewed. For peer-reviewed publications, please list either **published** or in **press**, but ***not*** "in review". For non peer-reviewed publications, please provide a hyperlink or webpage wherever possible. **Important: include a comprehensive list of publications as an appendix.**

Tamara Wall and colleagues has been developing an evaluation approach to determine the impact of the RISAs, and other climate service groups such as the Department of Interior's Climate Science Centers. A paper on the topic was published this year and provided a foundation of how climate services groups can evaluate their impacts. This includes the vocabulary to define different types of use of information, conceptual, instrumental and justification. The paper also provides 45 different metrics to use in evaluating a project. Publication of the paper and presenting on the ideas included in it are important steps in developing evaluation programs for climate services groups.

- Wall, T. U., A. M. Meadow, A. M. Horangic, 2017: Developing Evaluation Indicators to Improve the Process of Co-Producing Usable Climate Science, *Weather, Climate, and Society*, **9**, doi: 10.1175/wcas-d-16-0008.

The State of the Bay Delta Science Report was released for which Dettinger was a leading author and Cayan was a participating author. The Bay-Delta is an ecological

diverse and political complicated estuary where two major rivers in California converge, and eventually drain through San Francisco Bay. The Bay Delta is a critical component of water resource management in California in part because water is transported from north to south through the Bay-Delta. The State of the Bay Delta Science Report details the current understanding of the status of the Bay-Delta, projected impacts on it from climate change and provides suggestions for policy makers on paths forward. The entire report can be found at http://sbds.deltacouncil.ca.gov .The citation for the paper detailing climate impacts on the Bay-Delta is:

- Dettinger, M., J. Anderson, M. Anderson, L. Brown, D. Cayan, and E. Maurer, 2016, Climate change and the Delta: San Francisco Estuary and Watershed Science, 26 p., doi:10.15447/sfews.2016v14iss3art4.

The West Wide Drought Tracker has been operational since 2012 and has been gaining use and popularity. A publication for documentation has been John Abatzoglou and CNAP researcher McEvoy collaborated to write a BAMS article this now available in early online release.

- Abatzoglou, J. T., D. J. McEvoy, and K. T. Redmond, 2017: The West Wide Drought Tracker: Drought Monitoring at Fine Spatial Scales. *Bull. Amer. Meteor. Soc.*, doi:10.1175/BAMS-D-16-0193.1 (in press).

And new paper, that Westerling was a co-author on, examined how different variables influence the forecasting of wildfires. Results show that the inclusion of both vegetation and fire-year climate predictors was critical for model skill in identifying fires with high fractional fire severity. The inclusion of fire-year climate variables allows this model to forecast inter-annual variability in areas at future risk of high severity fire, beyond what slower-changing fuel conditions alone can accomplish. This allows for more targeted land management, including resource allocation for fuels reduction treatments to decrease the risk of high severity fire.

- Keyser, A.R. & A. L. Westerling, 2017: Climate drives inter-annual variability in probability of high severity fire occurrence in the western United States. *Environmental Research Letters,* doi: 10.1088/1748-9326/aa6b10.

The mechanisms driving daily variability of summer coastal low cloudiness (CLC) along the California coast is examined using daily CLC is derived from a satellite record from 1996 to 2014. Atmospheric rather than oceanic processes are mostly responsible for daily fluctuations in vertical stability that dictate short-period variation in CLC structure. Daily CLC anomalies are most strongly correlated to lower tropospheric stability anomalies to the north. The spatially offset nature of the cloud-stability relationship is a result of the balancing act that affects low cloudiness wherein subsidence drives increased stability, which promotes cloudiness, but too much subsidence limits cloudiness. Lay explanations claim that high inland temperatures “pull in” CLC, but such a process presumably would have the high temperatures directly inland. Rather, we find that the spatially offset

associations between CLC and atmospheric circulation result in positive correlations between CLC and inland surface temperature anomalies to the north. CLC are poorly represented in climate models and through this improved understanding of the mechanism responsible for CLC in California may help determine which climate models best represent the mechanism responsible for CLC and how they may impact heat waves in the future.

- Clemesha, R.E., A. Gershunov, S.F. Iacobellis and D.R. Cayan, 2017: Daily Variability of California Coastal Low Cloudiness: A Balancing Act between Stability and Subsidence. *Geophysical Research Letters*, 44, 3330–3338, doi:10.1002/2017GL073075

12. Please provide up to 3 narrative **examples** from the past year of plans, policies, strategies, tools, agreements, etc. that were proposed, adopted, and/or implemented as a result of RISA work. Please describe the role of RISA in achieving the accomplishments described and any associated socio-economic benefits.

As reported in the last CNAP annual report, Cayan, Kalansky, Iacobellis and Pierce developed new sea level projections for California. The new projections include the possibility of a much larger contribution from Antarctica to sea level rise based on Deconto and Pollard (2016) new ice modeling. Since developing these new projections, Cayan served on the Ocean Protection Council Science Advisory Committee, which just this April developed the *Rising Seas in California; An Update on Sea-Level Rise Science*. This document is the current state of the science for sea level rise for California and is the first step for California to update state-wide guidance on how to incorporate sea level rise in planning.

North American and Pacific Islands daily station data precipitation maps (http://cefa.dri.edu/ACIS/acis_pcp.php) were originally developed for the North American wildland fire management communities. Drought Monitor authors asked for some refinements. The product is currently being used to inform the monthly to seasonal wildland fire outlooks and the Drought Monitor map.

Complimenting existing work with the Bishop Piaute Tribe, Wall, McEvoy, and VanderMolen have begun working with the Washoe Tribe of Nevada to develop products related to climate change and impacts on Tribal lands/resources. Additionally, the Elko Band (Nevada) has contacted Wall regarding climate resiliency planning. These recent discussion with the tribes in Nevada are the results of continual engagement over the years that began with the Great Basin Climate Forum and other efforts to discuss resilience planning with the tribes in the region.

13. [*Only for teams that receive NIDIS-Coping with Drought funds for work on the NIDIS Regional Drought Early Warning System*]: Please describe how the research contributed to drought early warning technique or capabilities in the

region and/or methodologies that advance the early warning systems. Areas could include improvements in monitoring, forecasting, impact assessment, identification of vulnerability and risks, aligning capabilities with planning and preparedness (e.g. indicators, thresholds,) evaluation of early warning, and improving awareness and communication about drought and drought response.

Improving Drought Awareness and Communication

Co-Hosted with NIDIS, Four Drought & Climate Outlooks

- Riverside, CA https://www.drought.gov/drought/calendar/events/ca-nv-drought-early-warning-system-southern-california-drought-outlook
- Seaside, CA https://www.drought.gov/drought/calendar/events/north-central-coast-drought-climate-outlook-oct-11
- Fresno, CA https://www.drought.gov/drought/calendar/events/central-valley-drought-climate-outlook-oct-12
- San Diego, CA https://www.drought.gov/drought/calendar/events/ca-nv-dews-southern-california-winter-status-update-feb-9

These meetings focused on past, present and/or expected drought impacts, and offered an opportunity for stakeholders to interact with other decision makers and information providers in the region. The event had three purposes:

1. Provide an update on current and forecasted drought & climate conditions
2. Showcase current research and tools available to stakeholders to support drought early warning
3. Gather feedback from stakeholders on current needs for the CA-NV Drought Early Warning System to help inform the development of the CA-NV DEWS Strategic Plan

Co-Hosting with NIDIS Bimonthly Drought & Climate Outlook Webinar

The California-Nevada Drought Early Warning System (CA-NV DEWS) Drought & Climate Outlook Webinars are part of a series of regular drought and climate outlook webinars designed to provide stakeholders and other interested parties in the region with timely information on current drought status and impacts, as well as a preview of current and developing climatic events (i.e. El Niño and La Niña). The webinar takes place on the 4th Monday every two months. Example: https://www.drought.gov/drought/calendar/events/california-nevada-drought-climate-outlook-webinar-may-30

A special case of this outreach and monitoring is CNAPs development of the California and regional "Water Tracker", a tool that was developed during the recent 2012-2016 drought to supply information needs by Southern California Public Broadcasting Outlets (KPBS in San Diego and KPCC in Pasadena; see e.g. http://www.kpbs.org/news/2017/jan/09/kpbs-drought-tracker-update-weekend-storms-deliver/ and http://cirrus.ucsd.edu/~pierce/sdprecip/). This tracking continued into the most recent water year as well. Along with the monitoring efforts, Cayan, Pierce and Iacobellis have contributed semi-regular interviews with the KPBS reporters to discuss

the current water status that air on the radio. These monitoring efforts are complemented by a snow and water storage tracking tool developed and maintained by USGS colleague Mike Dettinger: https://scripps.ucsd.edu/programs/cnap/water-storage-tracking-in-california/.

Improved Monitoring

CNAP research Jordan Goodrich is working towards developing near-real-time estimates of groundwater pumping for the Central Valley. Current delays in these estimates stem from the difficulty and time required to access and compile all the necessary inputs to the Central Valley Hydrologic Model (CVHM). We have developed a statistical framework for simulating the primary inputs to CVHM, namely stream inflows and streamflow diversions, based on easily acquired data products such as gridded precipitation and evaporation from PRISM (PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created 4 Feb 2004). In CVHM, groundwater pumping is calculated as the water demand that is not met by surface water deliveries and precipitation. Therefore, we have focused our initial efforts on detailed characterization of the variability in reported surface water diversions and inflows. We leverage the generally predictable seasonal behavior and spatial variability with relationships to meteorological drivers to simulate these critical model inputs. A paper in preparation with this information and the next steps are to test these simulated inputs and compare resulting groundwater usage to the published USGS estimates, which will feed into an online tool for stake-holders to visualize current estimates of groundwater status for the Central Valley.

Improved Forecasting
Please see 2nd entry under question 9. CNAP researcher Shukla, is evaluating the skill of NMME forecasts at extended subseasonal to seasonal (S2S) timescales to support the improvement of drought early warning in California and Nevada.

For awards that started after February 2016, please describe your progress in implementing the Data Management Plan outlined in your proposal. *Please report all **data sets produced through this project.** Please provide for each:*

- *Data set name and description*
- *Availability (e.g., web address, NOAA archive location, data manager contact info)*

N/A

14. Please fill out the attached project database template for projects that meet all of the following criteria (NOTE: These criteria are generally a judgment call on the part of the Principal Investigator(s) and/or the Program Managers and do not require extensive analysis. Criteria should NOT be listed in database.):

    - Core RISA projects – Determined by one or more of the following:

i. RISA investigator is leading the effort
ii. RISA is primary source of funding
iii. RISA capacity is critical to the project (e.g. Regional Chapters/Technical Inputs of the NCA)

- Current projects – Determined by one or more of the following:
  i. Recently completed (i.e. finished within the last six months)
  ii. Ongoing (i.e. initiated, but not completed)
  iii. Planned (i.e. funded but not started)

Appendix List of Publications

Abatzoglou, J. T., D. J. McEvoy, and K. T. Redmond, 2017: The West Wide Drought Tracker: Drought Monitoring at Fine Spatial Scales. *Bull. Amer. Meteor. Soc.*, doi:10.1175/BAMS-D-16-0193.1 (in press)

Albano, C., M. Dettinger, and C. Soulard, 2017: Influence of atmospheric rivers on vegetation productivity and fire patterns in the Southwestern US, *Journal of Geophysical Research--Biogeosciences*, 16 p., doi:10.1002/2016JG003608.

Clemesha, R.E., A.Gershunov, S.F. Iacobellis and D.R. Cayan, 2017: Daily Variability of California Coastal Low Cloudiness: A Balancing Act between Stability and Subsidence, *Geophysical Research Letters*, 44, 3330–3338, doi:10.1002/2017GL073075.

Dettinger, M., J. Anderson, M. Anderson, L. Brown, D. Cayan, and E. Maurer, 2016: Climate change and the Delta, *San Francisco Estuary and Watershed Science,* 26 p., doi:10.15447/sfews.2016v14iss3art4.

Dorman, C., D. Koracin, J.F. Mejia, and D.J. McEvoy, 2017: World Marine Fog Occurrence. In *Marine Fog: Challenges and Advancements in Observations*, *Modeling and Forecasting,* D. Koracin and C. Dorman (Eds.), Springer International Publishing. [Available at: http://www.springer.com/us/book/9783319452272]

Griggs, Gary, Joseph Árvai, Dan Cayan, Robert DeConto, Jenn Fox, Helen Amanda Fricker, Robert E. Kopp, Claudia Tebaldi, and Elizabeth A. Whiteman. 2017. "Rising Seas in California: An Update on Sea-Level Rise Science." California Ocean Science Trust, /ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

Harpold, A., M. Dettinger, and S. Rajagopal, 2017: Defining snow drought and why it matters, *Eos, Transactions of the AGU,* 98(5), 15-17, https://eos.org/opinions/defining-snow-drought-and-why-it-matters[eos.org]

Healey, M., M. Dettinger, and R. Norgaard, 2016: Perspectives on Bay-Delta Science and Policy, *San Francisco Estuary and Watershed Science,* 14(4), 25 p., *http://dx.doi.org/10.15447/sfews.2016v14iss4art6*

Healey, M., P. Goodwin, M. Dettinger, and R. Norgaard, 2016: The State of Bay Delta Science 2016—An introduction, *San Francisco Estuary and Watershed Sci.*, 14(2), 7 p.

Hobbins M.T, D. J., McEvoy, and C. Hain, 2017: Chapter 11: Evapotranspiration, Evaporative Demand, and Drought, In: *Drought and Water Crises: Science, Technology and Management Issues*, edited by D Wilhite and R Pulwarty, CRC Press. (Accepted)

Huntington, J. L., K. Hegewisch, B. Daudert, C. Morton, J. Abatzoglou, D. J. McEvoy, and T. Erickson, 2017: Climate Engine: Cloud Computing and Visualization of Climate and Remote Sensing Data for Enhanced Natural Resource Monitoring and Process Understanding. *Bull. Amer. Meteor. Soc.,* doi:10.1175/BAMS-D-15- 00324.1 (in press)

Johannis, M., L. Flint, M. Dettinger, A. Flint, and R. Ochoa, 2016: The role of snowpack, rainfall, and reservoirs in buffering California against drought effects, *US Geological Survey Fact Sheet* 2016-3062, 2 p.

Keyser, A.R. & A. L. Westerling, 2017: Climate drives inter-annual variability in probability of high severity fire occurrence in the western United States. *Environmental Research Letters,* doi: 10.1088/1748-9326/aa6b10.

Lubetkin, K., L. Kueppers, and A. L. Westerling, 2017: Climate and landscape drive conifer encroachment into subalpine meadows in the central Sierra Nevada, California. *Ecological Applications.*

Lundquist, J.D., J. Roche, H. Forrester, B, Huggett, C. Moore, E. Keenan, G. Perry, N. Cristea, B. Henn, K. Lapo, B. McGurk, D. Cayan, and M. Dettinger, 2016: Yosemite Hydroclimate Network—Distributed stream and atmospheric data for the Tuolumne River watershed and surroundings, *Water Resources Research* (Technical Reports—Data) 52, 2112 p., doi:10.1002/2016WR019261.

Muth, M., K. Anderson, D. Brown, T. Brown, E. Delgado, G. Garfin, T. Hadwen, V. Murphy, R. P. Ramírez, B. Pugh, J. H. R. Gutiérrez, R. Heim, B. Rippey, and M. Svoboda, 2017: Advancing preparedness and response to drought and wildfires through North American transboundary collaboration. *Bulletin of the American Meteorological Society*, ES57-60. DOI:10.1175/BAMS-D-16-0296.1

Porter, K., D. Cox, M. Dettinger, and F. M. Ralph, 2016: The ARkStorm scenario—California's other "big one", *Natural Hazards Review*, 17(4), A2016000-1 – A2016000-2, 10.1061/(ASCE)NH.1527-6996.0000234 , A2016001.

Wall, T. U., A. M. Meadow, A. M. Horangic, 2017: Developing Evaluation Indicators to Improve the Process of Co-Producing Usable Climate Science, *Weather, Climate, and Society*, **9**, doi: 10.1175/wcas-d-16-0008.1.

Wall, T., T. Brown, and N. Nauslar, 2017: Spot Weather Forecasts: Improving Utilization, Communication, and Perceptions of Accuracy in Sophisticated User Groups**.** *Weather, Climate, and Society*, **9**, 215-226.

White, C.J., multiple authors including T. Brown, 2017: Applications of subseasonal-to-seasonal (S2S) predictions. *Meteorological Applications*, DOI: 10.1002/met.1654.

Publications still in Review

Clemesha, R.E., A. Gershunov, K. Guirguis, A.Tardy and I. Small, 2017: California heat waves: their spatial evolution, variation and coastal modulation by low clouds. *Climate Dynamics*, in review.

Crockett, J. and A.L. Westerling, 2017, Greater temperature and precipitation extremes intensify Western US droughts, wildfire severity, and Sierra Nevada tree mortality. *Journal of Climate*, in review.

Guirguis, K., A. Gershunov, D.R. Cayan and D. Pierce, 2017: Heat wave probability in the changing climate of the Southwest US. *Climate Dynamics, in review*.

Malig, B.J., T. Sherbakov, R. Basu, K. Guirguis, A. Gershunov, 2017: Ambient Temperature and Added Heat Wave Effects on Hospitalizations in California from 1999-2009. *Environmental Research*, in review.

Polade, S.D., A. Gershunov, D.R. Cayan, M.D. Dettinger and D.W. Pierce, 2017: Precipitation in a warming world: Assessing projected hydro-climate of California and other Mediterranean climate regions. *Nature Scientific Reports*, in review.